3SPACE®

FastSCAN Cobra™

Handheld Laser Scanner

February 2004

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Colchester, Vermont USA

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FCC STATEMENT

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause interference to radio communications. Operation of this equipment in a residential area is likely to cause interference, in which case the user will be required to correct the interference at his own expense.

LASER WARNING

A laser produces the red light emitted by this product. The laser is a specialized form of light source. Although the power of the laser is very low, laser light is concentrated into a very narrow beam. This property makes it useful in many applications, but also requires that precautions be taken to avoid damaging eyesight. Lasers are grouped into different classes, according to the degree of potential hazard they present. Class 1 lasers are safe under any circumstances. The laser in this device has a peak power of one milliwatt, at a wavelength of 670 nanometers, and falls into Class 2. Prolonged staring into the beam can damage the retina at the back of the eye. However, the eye has an aversion to such a bright light, and the natural reflex of someone exposed to the beam is to either blink or look away. This happens so quickly that no harmful effects occur. Prolonged staring into a reflection of the beam from a mirror or shiny metal surface may also be harmful, but a more diffuse reflection, off skin for example, is not hazardous.

For safe operation of this device, the following precautions should be taken:

- Never stare into the beam.
- If the device is used to obtain body profiles, warn subjects not to stare into the beam. Young children, or subjects whose natural aversion reflex may be dulled due to medication or a medical condition, may be advised to wear a blindfold.
- Operate the device so that it is pointing away from windows, doors, mirrors and other shiny reflective surfaces, and areas where other people are working.
- There are no controls, adjustments or user serviceable parts that can affect the laser output. In the event of equipment failure, return the Wand to the manufacturer or agent for repair and servicing.

Caution: Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous laser radiation exposure

The product includes the following safety features:

- The laser is only activated when the spring-loaded rocker switch (trigger) is depressed.
- An indicator light is illuminated when the laser is operating.
- All controls can be operated without direct viewing of the beam.
- Warning labels and a label indicating the laser aperture are attached to the Wand in the positions indicated on the following figures:

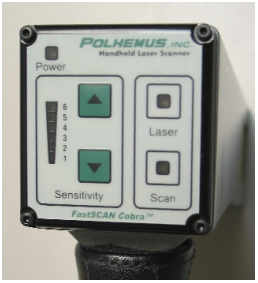
WARNING LABELS AND LOCATIONS

(a) The Wand displaying warning labels.

LASER LIGHT
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT
PEAK POWER 1mW, WAVELENGTH 670nm
Complies With: IEC 825-1:1993
& 21 CFR Chapter 1, Subchapter J
AVOID EXPOSURE - LASER LIGHT
EMITTED FROM THIS APERTURE

(b) Warning labels.

(c) Close-up of the laser aperture (circled), and two-position trigger switch (bottom).



(d) Wand control panel showing laser-on indicator light (top-right LED).

About This Manual

Use this manual to learn about:

- How your FastSCAN Cobra works.
- Setting up your computer and the FastSCAN Cobra.
- Setting up a suitable environment for scanning.
- General scanning principles for best results.
- Basic operation of the FastSCAN program.
- What to do if you get stuck.

You can find detailed help for the FastSCAN program in the **Help** menu. Note that you can print sections of the FastSCAN On-line Help from the Windows help utility if desired.

You may also need to refer to your computer hardware manual and Windows guides.

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1 Introduction

The FastSCAN Cobra Handheld Laser Scanner will quickly and conveniently digitize the three-dimensional surface of an object. Scanning involves smoothly sweeping the FastSCAN Cobra's "Wand" over the object, in a manner similar to spray painting. An image of the object appears simultaneously on the computer screen. Processing of the finished scan combines overlapping sweeps and eliminates redundant 3D points. The resulting 3D surface can be exported in a range of industry standard formats for loading into other programs.

A laser scanner consists of a non-contact range finder based on projection and simultaneous detection of laser light, coupled with a means of tracking the position and orientation of the range finder as it is scanned over the object's surface. In the FastSCAN Cobra, the range finding optics are contained in the handheld Wand, and the tracking is done with a Polhemus FASTRAK® magnetic tracker. Both the video processing and tracker electronics are contained in the Processing Unit (PU).

The complete FastSCAN Cobra Handheld Laser Scanner system is shown in Figure 1.

Figure 1: The FastSCAN Cobra system, which includes the Wand (top), the Processing Unit (bottom), the Transmitter (central cube), and the optional stylus (top right).

1.1 The Wand

The Wand consists of a centrally mounted laser line generator and a miniature camera, and is shown in Figure 2. The operator points the Wand at the object, and the camera on the Wand records the intersection of the laser line and the object, i.e., a profile. The three dimensional location of the profile with respect to the Wand is computed using triangulation. The operator scans the complete object by sweeping the Wand over different parts of the surface, collecting many profiles grouped into several sweeps.

Figure 2: The FastSCAN Cobra Wand.

If the laser profile is obscured from the camera, as can occur by a protrusion from the object, or a crevice, then you cannot scan that part of the surface with the current orientation of the Wand. Reorienting the Wand may allow scanning of troublesome areas. Objects too close (< 80 mm) or too far away (> 220 mm) will be outside the field of view of the camera.

A red filter and a polarizing filter on the camera enhances the laser contrast, but very dark, very shiny or translucent surfaces may not produce sufficient laser contrast for the FastSCAN Cobra to detect a profile.

Handling the Wand

- The Wand is a sensitive optical instrument – handle with care at all times.
- During scanning, place the Wand carefully on the Wand pad when not in use.
- After scanning, return the Wand to its protective case. When the Wand is in its protective case, always switch it off to avoid overheating.

The Wand has two controls (the trigger and a sensitivity control), and four status indicators (power, laser, scan, and a sensitivity bar graph). The sensitivity control and all status indicators are located on the control panel, as shown in Figure 3, and the trigger is located on the underside of the hand-grip.

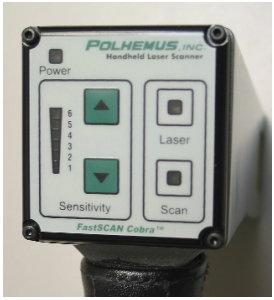


Figure 3: Detail of the Wand control panel.

1.1.1 The Trigger

A two-position trigger switch in the hand-grip of the Wand controls scanning:

Preview Position (trigger pulled in halfway)

- Displays laser profiles on the screen in real-time, but does not store them.
- Provides you with feedback to help in aligning successive sweeps in a scan and for filling in gaps.
- Used as a pointing aid to reorient the display on the computer screen to a "Wand's eye" view.

Scanning Position (trigger pulled in completely)

- Displays laser profiles and surface data on the screen in real-time and stores them in memory.

Additionally, double clicking the trigger will undo the last sweep, and triple clicking will initiate a new scan.

1.1.2 The Sensitivity Control

The sensitivity control consists of up and down buttons and a tapered bar graph that indicates the selected sensitivity of the Wand's camera. This is described in further detail in Section 5.4.

1.1.3 Status Indicators

The remaining status indicators are:

Power Lit whenever there is power to the Wand; i.e., the Wand is plugged in and the PU is turned on (top left corner of control panel).

Laser First lit when the trigger is pulled to the Preview Position, and also indicates that the laser is on (upper right on control panel).

Scan Lit when the trigger is pulled to the Scanning Position and the FastSCAN Cobra is on-line. Note that the **Laser** light remains illuminated with the trigger in the Scanning Position (lower right on control panel).

1.2 Processing Unit, Transmitter, and Receiver

As discussed above, the PU houses the electronics for the FASTRAK® magnetic tracker and the video processing electronics. The PU has connections for the Wand (video and receiver connections), the Transmitter, the Reference Receiver (also referred to as simply the Receiver), computer interface (ECP parallel port or USB) and power. The PU and its connections are shown in Figure 4.

One receiver mounted in the Wand allows the computer to determine the position and orientation of the Wand at all times, and hence locates each profile relative to the Transmitter. Similarly, by placing the Reference Receiver on the object, and selecting it to be the reference device, the computer can locate each profile relative to the object. This makes it possible to move the object during scanning. The Reference Receiver is shown in Figure 5(a). See Section 5.6 for more information.

The Transmitter generates a magnetic field that varies in three dimensions. The amplitude of the magnetic field it generates determines the position and orientation of each receiver. Any metal in the vicinity that deforms the magnetic field will distort the computed position and orientation of a receiver, and hence distort the scanned image. Increasing the separation of the metal from the Transmitter can significantly diminish these metal effects. It is shown in Figure 5(b).

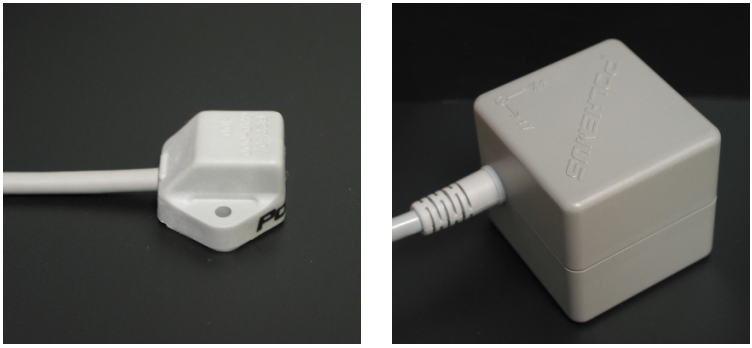
Finally note that any FastSCAN system cannot operate in the same vicinity with any other which is operating at the same frequency. If you are requiring to use two or more FastSCAN systems close to one another, please contact Polhemus for details on changing frequency.

(a) Front view.

(b) Back view, USB version.

(c) Back view, parallel port version.

Figure 4: The Processing Unit.



(a) (b)

Figure 5: The Reference Receiver (a) and Transmitter (b).

1.3 Component Separation and System Accuracy

Range is the most important factor in determining the quality and accuracy of the scan, for all the following reasons:

- The resolution of the range finding optics depends on the angle between the laser and the camera, and diminishes with increasing Wand to object distance.
- The accuracy of the magnetic tracker depends on the strength of the magnetic field, and so diminishes with increasing separation between transmitter and receiver.
- The accuracy of surface calculations is sensitive to rotation errors of the tracker receivers, such that surface accuracy diminishes with increasing distance between object and receivers.

Therefore in order to obtain the best results when scanning, try as much as possible to:

- Keep the Wand close to the object's surface (about $100 - 150$ mm for a small object).
- Keep the Wand close to the Transmitter.
- If being used, attach the Reference Receiver close to the part of the object that you are scanning and keep the Reference Receiver close to the Transmitter.

1.4 Software

The FastSCAN Cobra system includes proprietary FastSCAN software for data acquisition and exporting. It runs on NT4, Windows 2000 or XP. It is provided on a CD-ROM.

1.5 Licensing

The license file is supplied as a self extracting executable, `FastSCAN.lic.exe`, which when run saves the license file `FastSCAN.lic` in the same directory as the FastSCAN executable.

The license file contains one or more licenses. To view the status of any licenses (i.e., presence of license(s) and expiration date), select **Licenses** from the **File** menu.

The license enables and disables various aspects of the FastSCAN software, and may be associated with an expiry date. Licensed features include:

Wand The FastSCAN Wand license uniquely identifies the Wand. Note that if this license is not present, the expiry date has passed, or the Wand number is incorrect, the FastSCAN software will still operate, but you will be unable to save or export the data you collect.

FastRBF License If FastRBF is not present in your license, then the FastRBF Extensions will operate in 'demo' mode, which allows you to process and view any scan with the FastRBF engine, but prevents you from saving the output surface.

Optical Stylus Enables the optical stylus feature, that turns your FastSCAN Cobra into an optical point digitizer. Note that an optical stylus shutter is also required.

AAOP Export The file format named after the American Academy of Orthotists and Prosthetists (AAOP) is exportable via the **AAOP Export Wizard**. It is used by prosthetic and orthotic CAD/CAM vendors.

OP3 Wizard Enables the **OP3 Export Wizard**. The OP3 format is used by prosthetic and orthotic CAD/CAM vendors.

2 Hardware Setup

2.1 Computer Requirements

Computer requirements are as follows:

- Microsoft Windows NT 4 (with Service Pack 3 or above) Windows 2000 (with Service Pack 1 or above), or Windows XP (with Service Pack 1 or above).
- Intel Pentium III 500 MHz equivalent or better.
- Recommend 256 MB RAM or greater.
- OpenGL hardware accelerated graphics adapter in 32-bit (true color) mode.
- ISA (or on-board) parallel port supporting ECP mode with DMA, *or* USB. The operating systems and the computer interface(s) they support are summarized in the table below:

	NT4	Windows 2000	XP
Parallel port	√	√	
USB		√	√

i.e., USB is the only available interface for Windows XP.

Warning for Parallel Port Users

FastSCAN must have exclusive use of the parallel port in order to maintain communication with the host computer. It cannot share the port with a printer, scanner, dongle or other parallel port device.

Before installing FastSCAN, ensure that the computer has the appropriate operating system and service pack installed according to the computer manual. Turn the computer on and check that it works correctly before installing the FastSCAN software.

2.2 Unpacking

When you unpack your FastSCAN Cobra check that the following components are included:

- Protective case, containing:
  - Wand.
  - Processing Unit.
  - The Processing Unit's power supply and power cable.

  - Transmitter (large cube).
  - Receiver (small cube).
  - Wand's detachable cable.
  - Wand pad.
  - Calibration Target and mounting screws.
- A plastic headband with mounting screws for the Receiver.
- ECP parallel port card (optional).
- Parallel port cable *or* USB cable.
- Software install CD.
- Calibration file, on a 3.5" floppy disk.
- This manual.

2.3 Parallel Port Configuration

This section describes how to configure an ECP-compliant parallel port to allow the PU to communicate with the FastSCAN software. If you are interfacing using USB, then this section can be disregarded, and continue reading at Section 2.4.

There are two parallel port options (LPT1 and LPT2) and you must decide which option best suits your computer system. Your computer will most likely be equipped with an ECP compatible parallel port (LPT1). If you wish to use LPT2, you will have to install the parallel port card supplied with FastSCAN. Details of the available options are:

LPT1 The standard parallel port incorporated in your computer.
- FastSCAN cannot share a parallel port. You will need to plug dongles, printers and scanners into a different port.
- LPT1 must be fully ECP compliant.
- You may need to change BIOS settings to switch LPT1 to ECP mode, and to enable DMA.

LPT2 Supplied with the FastSCAN as a separate card.
- A spare ISA slot is required to install the card.
- It is not possible to install the LPT2 card in a laptop.
- A suitably experienced person must install LPT2 into the host computer.

The following sections describe the configuration procedure for the two options. Follow the procedure for the LPT option you have chosen.

2.3.1 Option 1: LPT1 Configuration

1. Set the parallel port hardware on your computer (LPT1) to ECP only mode with DMA. Do not use the combined ECP/EPP mode. Some computers may have a BIOS configuration program for changing these settings, while others require you to enter the BIOS setup program during startup.
2. Only two DMA channels (1 and 3) are available for the parallel port. Normally LPT1 uses DMA channel 3, but some computers may only allow DMA channel 1. Select the appropriate DMA channel for LPT1 and take note of which one you have selected.
3. Restart your computer for the settings to take effect.

2.3.2 Option 2: LPT2 Installation

The second option is to use the ISA parallel port card supplied with FastSCAN. You can install this card as LPT2 and connect FastSCAN to it.

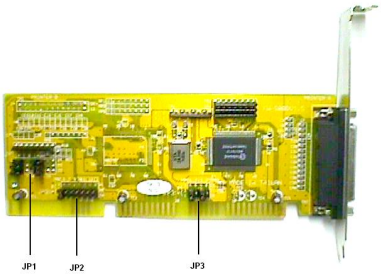
1. Locate the ISA parallel port card supplied with FastSCAN.
2. Ensure that the jumper settings on the card are correct. The jumpers on the parallel port card are factory set to address 278Hex, DMA1, DACK1, and IRQ5. See Section 2.3.4 for jumper setup details.
3. Install the card into a spare ISA slot.

2.3.3 Resolving Conflicts with Other Devices

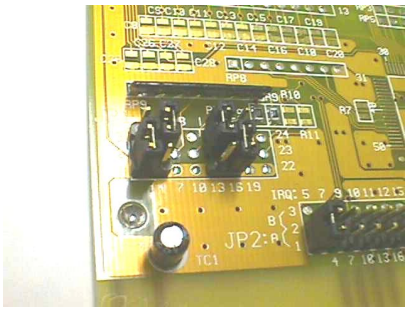
- The interrupt request (IRQ) settings for LPT1 and LPT2 are fixed; LPT1 uses IRQ7 and LPT2 uses IRQ5. Make sure that no other device is using the IRQ associated with the LPT port that you are using. A sound card or network card may also use IRQ5 or IRQ7.
- Ensure that no other device is using the DMA channel (1 or 3) you have selected. Typically, a sound card or network card may have used one or both of the available DMA channels. One of these two DMA channels must be available for the parallel port you are using.
- If you have trouble configuring the ECP port on your computer, try using the supplied parallel port card. If you plan to use a laptop computer, our testing of the IBM ThinkPad has found that is it fully ECP compliant. For other brands, check with your laptop vendor for information on their parallel port.

2.3.4 Jumper Setup Details

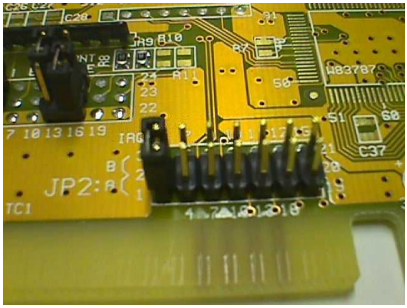
Figure 6(a) shows the identification of JP1, JP2, and JP3 on the supplied parallel port card. Set JP1 as shown in Figure 6(b), JP2 as shown in Figure 6(c), and JP3 as shown in Figure 6(d).



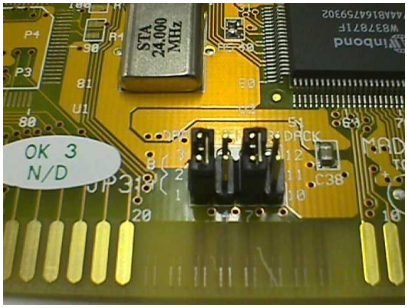
(a) Locations of three sets of jumpers.



(b) JP1—this configuration sets the parallel port address to 278Hex (LPT2) and the parallel port mode to ECP.



(c) JP2—this sets the interrupt to IRQ5.



(d) JP3—this sets the DACK and DMA to channel 1.

Figure 6: Parallel port card.

2.4 Plugging it Together

Place the PU near the computer and plug it into a power source or outlet. Connect the computer interface cable (USB or parallel port) to the back of the PU and to the computer, and, if applicable, taking care to choose the correct parallel port to use, i.e., LPT1 or LPT2 as selected above. Allow room for air circulation from the fan at the back of the PU.

Plug the yellow and green plugs of the detachable cable into the respective sockets on the Wand. Plug the two connectors at the other end of the detachable Wand cable into the sockets at the front of the PU labeled 'Wand' (i.e., in the two sockets on the left). Plug the Reference Receiver connector into the socket labeled 'Reference'; and plug the Transmitter connector into the socket labeled 'Transmitter'. The setup is shown in Figure 7.

Notes:

- *You **must** connect the Reference Receiver, even if you are not using it.*
- All connectors are different and polarized to avoid ambiguity, with the exception of the Wand receiver and Reference Receiver.
- You must always power the PU off before any of the front panel leads are connected or disconnected, or the Wand is detached from the detachable cable.

Figure 7: The FastSCAN Cobra system with all the components attached. Note that the power and computer interface cables are obscured behind the PU.

3 Windows NT4 Software Setup

Read this section only if you are installing the FastSCAN software on a computer running Windows NT4. See Section 4 if you are using Windows 2000 or XP.

3.1 Installing the Software

The software installation is in three stages: (1) install the program files, (2) install the calibration file of the Wand, and (3) install the license file. The installation procedure is as follows:

1. You must run the FastSCAN setup program with Administrator privileges.
2. The FastSCAN program files are supplied on a CD-ROM. Insert the CD, and the setup program should start automatically. If not, run `Setup.exe` using Windows Explorer, My Computer or the Windows **Start** menu **Run** option.
3. Setup will guide you through the installation of the FastSCAN software; it will copy the FastSCAN program files onto your system drive, and update the registry. You must then restart your computer for the installation to take effect.
4. Once the computer has restarted, load the calibration file of your Wand. The calibration file is on the 3.5" floppy disk in the Wand carrying case. Insert this disk in `A:` and run the file named `A:\Wand_xxx.exe`, where `xxx` is the serial number that matches your Wand.
5. Finally, install the license file. This includes the license that is unique to the supplied Wand. (See Section 1.5 for more details.) The license file will be supplied either on the 3.5" floppy disk containing the calibration file, or in some circumstances supplied via email. In either case, run the self extracting executable, namely `FastSCAN.lic.exe`. The license file will be saved along with the FastSCAN executable. If you have not yet received the license file, continue on with the software setup; the FastSCAN Cobra will still operate normally with the exception that data cannot be saved or exported. The license file can be installed at a later time.

Notes:

- Program settings are loaded from and saved to the Windows registry, where each user has their own personal settings.
- If you have a printer attached to the parallel port where you would normally attach FastSCAN then you will need to uncheck **Driver enabled** in the **Scanner Properties** dialog box in order to use the printer.

- To uninstall FastSCAN, use the **Add/Remove Programs** utility, located in the Windows control panel.

3.2 Configuring FastSCAN

Now you must configure the FastSCAN software to communicate with the parallel port driver before you will be able to use the scanner. This section assumes that you have performed all the tasks described in Section 2.3. The configuration procedure is as follows:

1. Turn on the computer and log on to Windows with Administrator privileges.

2. Turn on the PU with the switch on the back panel. The green light on the front panel of the PU should flash several times then remain on—a process that takes approximately 10 seconds. Otherwise a problem initializing the PU has occurred. If this situation occurs turn the PU off, then back on, and check that the light flashes as described above.

3. The Power light on the Wand should be on. If not check that the Wand's detachable cable is correctly attached at either end, noting that the PU must be powered down before any cabling is removed or attached at the PU or Wand.

4. Start the FastSCAN Program by double clicking on the Desktop Icon, or via the Windows **Start / Programs / Polhemus FastSCAN** menu.

5. Ensure that **Driver enabled** is checked in the **Scanner Properties** dialog box (accessed from **Scanner / Properties**).

6. In the **Scanner Properties** dialog box select the **LPT port** and **DMA** that you chose when configuring the parallel port (see Section 2.3).

7. In the **Scanner Properties** dialog box select the correct **Hardware version** of your PU. The default is 1, which is correct for recent models. If however, your PU looks unlike the one in Figure 4, and is rather larger, the correct version is 0.

8. If the configuration you have entered is correct and the FastSCAN software is communicating with the parallel port, the **Driver status** indicator will show 'ok'. If the **Driver status** indicator shows 'Error', see the **Explanation** section of the dialog box for details.

9. With the PU connected to the parallel port, the **Explanation** section will indicate that the scanner is initializing (for approximately 10 seconds) and then indicate that the PU is on-line. (With the PU *not* connected to the parallel port, the **Explanation** section will indicate that the PU is off-line).

10. After the initialization is complete (PU is on-line), pull the trigger on the Wand. A dialog box will prompt you to define the hemisphere of operation—follow the instructions in the dialog box.

11. FastSCAN is now ready for use.

Notes:

- If you change your parallel port hardware, or choose to use a different parallel port, then you will need to repeat the configuration in Section 3.2.
- With some older parallel port hardware that does not fully support ECP, the FastSCAN software may not be able to detect and report problems. For example, the scanner may not come on-line while not reporting any errors. Also, the scanner may come on-line but not respond to the Wand trigger actions.

4 Windows 2000 and XP Software Setup

Read this section only if you are installing the FastSCAN software on a computer running Windows 2000 or XP. See Section 3 if you are using Windows NT4.

4.1 Installing the Software

The software installation is in three stages: (1) install the program files, (2) install the calibration file of the Wand, and (3) install the license file. The installation procedure is as follows:

1. You must run the FastSCAN setup program with Administrator privileges.
2. The FastSCAN program files are supplied on a CD-ROM. Insert the CD, and the setup program should start automatically. If not, run `Setup.exe` using Windows Explorer, My Computer or the Windows **Start** menu **Run** option.
3. Setup will guide you through the installation of the FastSCAN software; it will copy the FastSCAN program files onto your system drive, and update the registry. You must then restart your computer for the installation to take effect.
4. Once the computer has restarted, load the calibration file of your Wand. The calibration file is on the 3.5" floppy disk in the Wand carrying case. Insert this disk in `A:` and run the file named `A:\Wand_xxx.exe`, where `xxx` is the serial number that matches your Wand.
5. Finally, install the license file. This includes the license that is unique to the supplied Wand. (See Section 1.5 for more details.) The license file will be supplied either on the 3.5" floppy disk containing the calibration file, or in some circumstances supplied via email. In either case, run the self extracting executable, namely `FastSCAN.lic.exe`. The license file will be saved along with the FastSCAN executable. If you have not yet received the license file, continue on with the software setup; the FastSCAN Cobra will still operate normally with the exception that data cannot be saved or exported. The license file can be installed at a later time.

Notes:

- Program settings are loaded from and saved to the Windows registry, where each user has their own personal settings.
- If you have a printer attached to the parallel port where you would normally attach FastSCAN then you will need to uncheck **Driver enabled** in the **Scanner Properties** dialog box in order to use the printer.

- To uninstall FastSCAN, use the **Add/Remove Programs** utility, located in the Windows control panel.

4.2 Setting up the Computer Interface

For Windows 2000 installations you have a choice of either parallel port (4.2.1) or USB (4.2.2). For Windows XP, USB is the only option (4.2.2). See figure 4 to determine which type of PU you have.

4.2.1 Parallel Port

Before using the FastSCAN software, you must configure the parallel port and the FastSCAN device driver using the Device Manager. This section assumes that you have performed all the tasks described in Section 2.3.

To open the Device Manager:

1. Log on to Windows as a user with Administrator privileges.
2. From the Control Panel, open the **System** icon.
3. Select the **Hardware** tab.
4. Press the **Device Manager** button.

The following sections describe how to configure the parallel port FastSCAN device drivers. You will need to repeat these instructions if you decide to attach FastSCAN to a different parallel port.

Changing the interrupt setting

FastSCAN requires that its parallel port must use an interrupt, but this is not the default behavior under Windows 2000.

1. Expand the **Ports (COM & LPT)** sub-tree.
2. Locate your chosen parallel port (LPT1 or LPT2) inside this tree and open it.
3. Choose the **Port Settings** tab.
4. Select **Use any interrupt assigned to this port**.

FastSCAN Device Driver

1. Expand the **Virtual Ports** sub-tree.
2. Locate the FastSCAN device driver **ECP Device (WDM)** inside this tree and open it.
3. Choose the **Port Settings** tab.
4. Set the **Connect to LPT Port Number** control to the parallel port that you are using.

4.2.2 USB

Before using the FastSCAN software, you must setup the USB drivers. This section assumes that you have performed all the tasks described in Section 2.4, i.e., the system is correctly connected together, and the USB cable connects the PU to the computer.

The procedure is as follows:

1. Turn on the PU with the switch on the back panel. The green light on the front panel of the PU should flash several times then remain on—a process that takes approximately 10 seconds. Otherwise a problem initializing the PU has occurred. If this situation occurs turn the PU off, then back on, and check that the light flashes as described above.
2. The Power light on the Wand should be on. If not check that the Wand's detachable cable is correctly attached at either end, noting that the PU must be powered down before any cabling is removed or attached at the PU or Wand.
3. The computer should have recognized that the PU has been turned on, and a 'Found New Hardware' help bubble should appear, and launch the 'Found New Hardware Wizard'.
4. The Windows 2000 and XP 'Found New Hardware Wizard' interfaces work slightly differently, but the principle is the same. It is necessary to direct the 'Found New Hardware Wizard' to the FastSCAN USB driver. For convenience, the drivers are located in two places, and the Wizard can be directed at either. The first location is the CD, and if you are installing off CD it is usually easiest to use the Wizard's automatic (and the 'recommended') options which will automatically locate the USB drivers off the CD for you. The second, alternative location is in the subdirectory called `USB Driver` off the FastSCAN directory, which will normally be located as follows:

```
C:\Program Files\Polhemus\FastSCAN\USB Driver
```

If you are not installing from CD, for example if you have downloaded the install files from the Internet, then you will want to direct the Wizard to this location. Therefore, choose the option that allows the Wizard to obtain the drivers from a specific location, and specify the alternative location as described above. This will involve clicking on a **Browse** button in the Wizard to locate this directory. See Figure 8 which shows the completion of this task under Windows XP.

5. During the process you may be alerted that the FastSCAN USB software has not passed Windows Logo testing. Click the **Continue Anyway** button.

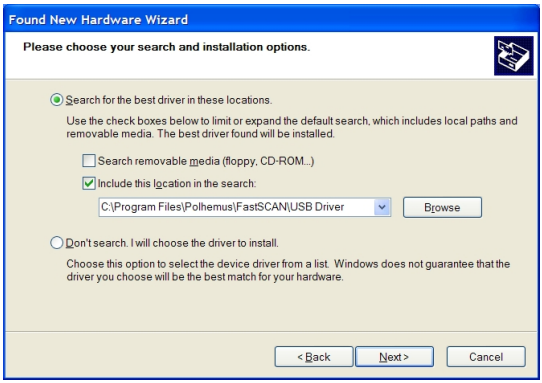

Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
C:\Program Files\Polhemus\FastSCAN\USB Driver
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Figure 8: 'Found New Hardware Wizard' showing the search location for the driver.

4.3 Running the FastSCAN Program

Now you must start the FastSCAN program to test the configuration. If you are performing a USB installation, the PU will already be switched on, in which case proceed to Step 3 below.

1. Turn on the PU with the switch on the back panel. The green light on the front panel of the PU should flash several times then remain on—a process that takes approximately 10 seconds. Otherwise a problem initializing the PU has occurred. If this situation occurs turn the PU off, then back on, and check that the light flashes as described above.

2. The Power light on the Wand should be on. If not check that the Wand's detachable cable is correctly attached at either end, noting that the PU must be powered down before any cabling is removed or attached at the PU or Wand.

3. Start the FastSCAN Program by double clicking on the Desktop Icon, or via the Windows **Start / Programs / Polhemus FastSCAN** menu.

4. Ensure that **Driver enabled** is checked in the **Scanner Properties** dialog box (accessed from **Scanner / Properties**).

5. For Windows 2000 installations, select the appropriate computer interface from the **Port Type** drop down box in the **Scanner Properties** dialog box, namely **Parallel** or **USB**. For Windows XP, only USB is supported, and so there is no choice to make.

6. In the **Scanner Properties** dialog box select the correct **Hardware version** of your PU. The default is 1, which is correct for recent models. If however, your PU looks unlike the one in Figure 4, and is rather larger, the correct version is 0.

7. If your configuration is correct and the FastSCAN software is communicating via the chosen interface, the **Driver status** indicator will show 'ok'. If the **Driver status** indicator shows 'Error', see the **Explanation** section of the dialog box for details.

8. With the PU connected via the parallel port or USB interface, the **Explanation** section will indicate that the scanner is initializing (for approximately 10 seconds) and then indicate that the PU is on-line. (With the PU *not* connected, the **Explanation** section will indicate that the PU is off-line).

9. After the initialization is complete (PU is on-line), pull the trigger on the Wand. A dialog box will prompt you to define the hemisphere of operation—follow the instructions in the dialog box.

10. FastSCAN is now ready for use.

Notes:

- You must run the Device Manager with Administrator privileges if any settings are to be changed.
- If you change your parallel port hardware, or choose to use a different parallel port, then you will need to repeat the parallel port and device driver configurations in Section 4.2.1.
- With some older parallel port hardware that does not fully support ECP, the FastSCAN software may not be able to detect and report problems. For example, the scanner may not come on-line while not reporting any errors. Also, the scanner may come on-line but not respond to the Wand trigger actions.
- If you replace your PU while using the same computer, you will be required to reinstall the USB drivers as described in Section 4.2.2.

5 Scanning

5.1 Scanning Environment

The scanning area ideally will be an area of subdued lighting, with no light from outside windows visible. Scanning errors can arise when the scanner's camera view's lights or windows (i.e., direct sources of bright, broad-spectrum light).

Move the Processing Unit, computer, and any other significant metal objects at least one meter away from the scanning area. A wooden table is an ideal surface on which to place objects for scanning.

For best results, it is important to always position the Transmitter as close as possible to the object that you are scanning. It is usually most convenient to place it behind or under the object. In the default **Transmitter is Reference** mode, it is vital that the object remains stationary relative to the Transmitter during a scan. If the object cannot remain stationary, then the Transmitter may be attached to the object, or alternatively the Reference Receiver may be attached and **Receiver is Reference** selected in the **Scanner** menu (refer to Section 5.6).

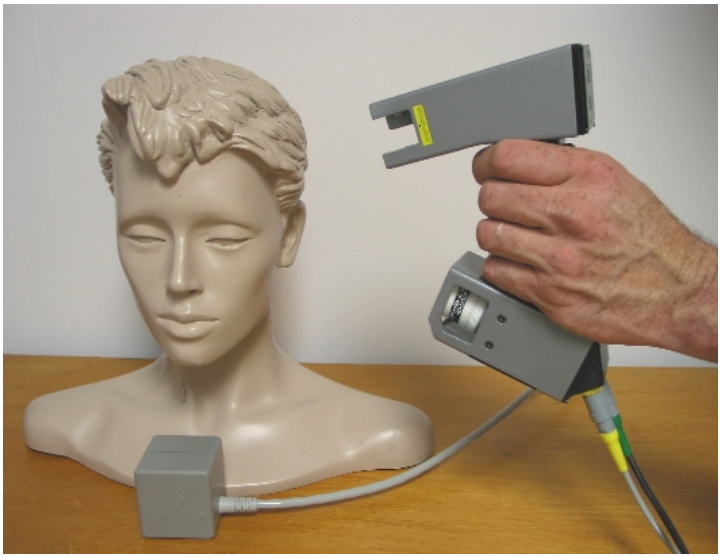


Figure 9: An example of scanning a model. Note the wooden table, placement of the Transmitter, and the orientation of the Wand.

5.2 Initiating a Scan

Ensure all the components of the FastSCAN Cobra are correctly connected and turned on, and the scanning environment has been setup appropriately as described in Section 5.1.

Log on to Windows and start the FastSCAN program by double clicking on the desktop icon or via the Windows **Start / Programs / Polhemus FastSCAN** menu.

You can start the program and turn on the scanner in any order, as the program checks for the presence of the scanner at regular intervals. If **Driver enabled** is unchecked in the **Scanner Properties** dialog box, then 'Scanner disabled' will appear in the lower right section of the status bar. Otherwise, with **Driver enabled** checked, the status bar will report 'Scanner on-line' or 'Scanner off-line' depending on whether or not the scanner is connected and turned on. As soon as the scanner is detected, the program will show 'Scanner initializing' in the status bar. Wait a few seconds until 'Scanner on-line' appears before trying to scan.

Note

The program may not be able to differentiate between FastSCAN and other equipment (such as a printer) connected to the parallel port.

The Wand trigger controls scanning. When you pull the trigger the FastSCAN program immediately prepares for scanning:

- If you were previously viewing an Export Surface (i.e., the surface produced following data processing—see Section 6) the program reverts to displaying the Raw Surface (i.e., the unprocessed data).
- If you have not already initialized the tracker hemispheres then a dialog box will appear. Follow the on-line instructions to initialize the tracker hemisphere:
  - Point the Wand at the appropriate reference device (the Transmitter or the Receiver, depending on which is the current reference).
  - Pull the Wand trigger briefly.
  - Press the **OK** button in the dialog box.

5.3 Previewing

The Preview Position (with the trigger pulled to the halfway position), enables the laser to be cast on the object without collecting any data. At the same time, a red line appears in the FastSCAN window on screen. If data has already been collected, the line in the FastSCAN window will be displayed relative to the rendered surface.

The second function of the Preview Position is to reorientate the surface on the display without having to return to the keyboard. This is performed simply by pointing the Wand at the object, pulling the trigger to the Preview Position such that a profile is displayed on screen, and releasing the trigger. The display will then automatically assume a "Wand's eye" view.

Note that this orientation facility can be disabled by unchecking the **Automatic Viewpoint** from the **Scanner** menu.

5.4 Setting the Sensitivity

Select **Camera** from the **View** menu.

The sensitivity control is used to adjust the camera sensitivity to compensate for different object surface types, colors, and varying environmental lighting conditions. It is located on the left side of the Wand control panel. Position 1 is the least sensitive while position 6 is the most sensitive.

You should adjust the sensitivity when scanning any new object.

1. Select **Camera** from the **View** menu.
2. Set the sensitivity control to position 1.
3. Pull the trigger to the Preview Position (halfway position).
4. Push the sensitivity control up arrow to increase the sensitivity. A red curve should become visible, which is the laser profile as viewed by the camera. If the curve never become visible, try moving the Wand towards or away from the object.
5. Set the sensitivity control to the lowest value that gives an unbroken red curve.

Note that on powering down the system, the Wand will remember the sensitivity control's last setting.

5.5 Scanning

Select **Raw Surface** from the **View** menu.

To scan a complete three-dimensional object you will need to perform a number of sweeps with the Wand. Each sweep of the Wand should be a *smooth action* as if spray painting. Do not move the Wand backwards and forwards rapidly in a jerky manner.

Successive sweeps should overlap slightly. You can rescan missing patches. Try to avoid repetitive scanning of the same part of the surface.

Preview the laser position on the computer monitor with the trigger in the Preview Position before starting each new sweep, to ensure an efficient overlap with the last sweeps. Perform the sweep by pressing the trigger into the scanning position and smoothly moving the Wand. Release the trigger at the end of the sweep. The orange Scan light on the back of the Wand lights up while you are scanning. You may erase the last sweep by using **Undo** or by double clicking the Wand trigger. Pulling the trigger into preview position is sufficient for double clicking.

As already discussed in Section 1.3, the accuracy of a measured point on the surface of an object is strongly dependent on the distance from the Wand to the surface of the object. This is because errors in the calculation of the Wand's orientation are amplified by the distance to the measurement point. Furthermore, the accuracy of the measured point is also dependent on the distance from the Wand to the Transmitter. *Keep the Wand as close to the surface you are scanning and as close to the Transmitter as conveniently possible*.

5.5.1 Best and Worst Scanning Resolution

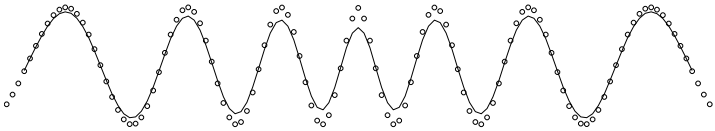
The speed at which you move the Wand over the surface of the object is the major determination of the resolution of the Raw Surface. However, in some situations one may wish to place a lower limit on the resolution at which data is collected; e.g., to reduce memory and processing requirements. This can be achieved by adjusting the **Best Scanning Resolution** in the **Scanner Limits Control** dialog box (accessed from **Scanner / Limits Control**). Similarly, you can control the maximum scanning resolution via the **Worst Scanning Resolution** in the **Scanner Limits Control** dialog box. Use this to avoid inadequate resolution when scanning very quickly, e.g., in order to maintain a desired accuracy and not miss important detail, or to avoid filling in holes. Selecting **Wireframe** from the **View** menu will allow you to experiment with different scanning speeds and **Best/Worst Scanning Resolution** values to assess the effect on resolution.

5.5.2 Profile Smoothing

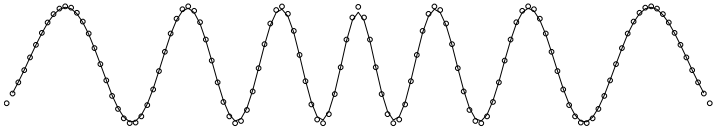
FastSCAN Cobra filters each profile as collects it, applying a degree of smoothing to the profile. This filter removes noise in the scanner data, but it will also remove surface details. A high value will smooth over measurement errors, but will also remove a lot of surface detail. Alternatively, a low value will preserve detail where it is present but will give a rougher surface.

A side effect of the profile smoothing is that some points are lost from the ends of each profile. If a profile has a gap in it (as might occur when scanning a hole in a surface) then points are also lost from both sides of the gap. More points are lost for higher smoothing values.

You can control the amount of smoothing using the **Profile Smoothing** option in the **Scanner Limits Control** dialog box (high, medium, low, or none). Changing this value affects newly captured profiles; it cannot change data that you have already collected. You may need to experiment to find the optimal value before you begin scanning. Figure 10 shows how smoothing can affect a profile.



(a) A profile with high smoothing.



(b) A profile with low smoothing.

Figure 10: Examples of profile smoothing applied to a single profile when scanning a corrugated surface. The dots are the original scanned points and the black line is the resulting profile. Note that high smoothing drops three points at the end of the profile, while low smoothing only drops one.

As well as the profile smoothing, the generation of an Export Surface (Section 6) applies a different type of smoothing. Unlike the profile filter, you can adjust and this 'export' smoothing *without* having to rescan your object.

5.6 Using the Receiver

If you attach the Reference Receiver to the object, you can move the object or Transmitter during scanning. You can also use a fixed Receiver to scan very large objects.

5.6.1 Scanning Moving or Unstable Objects

Attach the Receiver *firmly* to the object you are scanning. From the **Scanner** menu, select **Receiver is Reference**. Note that the Receiver becomes the origin of the Reference Coordinate System.

It is important to note that although the object and Transmitter can be moved, for example, held in the hand, *they should not be moved in a rapid or jerky manner*, a constraint that also applies to the Wand.

To achieve the best results, keep the Transmitter as close as practical to the Wand and Receiver. However, you must keep the Receiver at least 100 mm away from the Transmitter to avoid signal overload.

It is possible to remove the Receiver, allowing you to scan the part of the object where you attached the Receiver. Place the object and the Transmitter near to each other, remembering that, once you remove the Receiver, the object and the Transmitter must not move. Select **Freeze Receiver** from the **Scanner** menu; the software will provide detailed instructions.

5.6.2 Using the Headband

When scanning people, a subject will generally move their head involuntarily during scanning. You may largely overcome this problem by attaching the Receiver to the subject's head. A convenient method of attaching the receiver is with the plastic headband included with the FastSCAN Cobra. Attach the Receiver firmly to the headband with the nylon screws provided. Adjust the headband size to give a firm but comfortable fit, as shown in Figure 11.

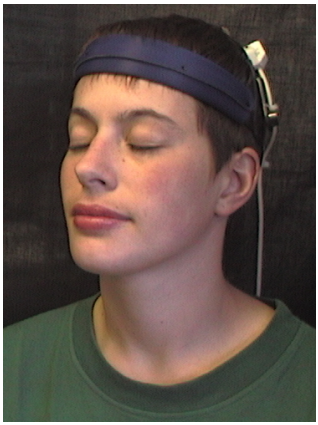


Figure 11: Using the Receiver attached to the headband.

5.6.3 Scanning Large Objects

You can use the Reference Receiver to scan extra large objects. To do this, fix the Receiver to the center of the object and place the Transmitter midway between the Receiver and the Wand. As you move around the object, also move the Transmitter, keeping it between 100 mm and 750 mm of the Receiver and Wand. Figure 12 illustrates this layout.

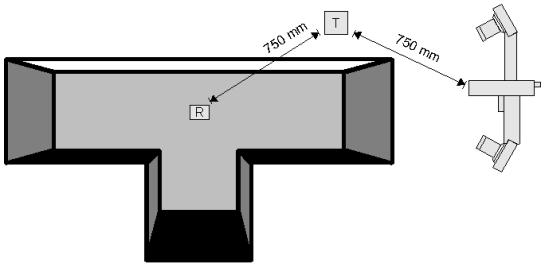


Figure 12: Example of scanning a large T-shaped object with the Receiver as Reference. R is the Receiver (fixed to the object) and T is the Transmitter.

5.7 Coordinate Systems

The FastSCAN program uses two coordinate systems: the Reference Coordinate System and the Screen Coordinate System.

You acquire the Raw Surface data in the Reference Coordinate System, where the Reference is either the Transmitter or the Receiver. You can change the Reference in the **Scanner** menu by selecting **Transmitter is Reference** (default) or **Receiver is Reference**. Markings on the side of the Transmitter indicate its coordinate system, but there are no such markings on the Receiver. Figure 13 shows the coordinate system of the Receiver.

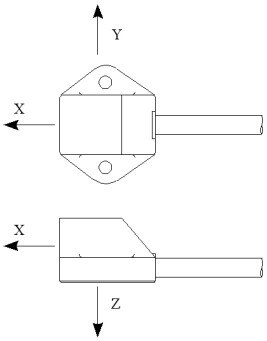


Figure 13: The coordinate system of the Reference Receiver.

The Screen Coordinate System has its x-axis pointing to the right, y-axis pointing up and z-axis pointing out of the center of the screen (a right-handed coordinate system).

The Viewpoint is the mapping from the Reference Coordinate System to the Screen Coordinate System, and includes any rotations, translations (change of origin) and zooms that have been made with the menu, mouse or keyboard.

The software saves the View Settings along with the data in the HLS file. This consists of all those settings associated with the Viewpoint as well as surface representation (**Points**, **Wireframe**, **Flat Shaded** or **Smooth Shaded**) and **Lighting, Color** settings. When loading a previously saved scan (HLS file) into the FastSCAN program you may optionally load these View Settings. Settings will be loaded if **Load view settings with scan** has been checked in the **Load a Scan File** dialog box (accessed via **File / Load**).

5.8 Changing the View

You can manipulate both the Raw Surface and Export Surface on the screen, using either the mouse (Section 5.8.1) or the keyboard (Sections 5.8.2 and 7), for these basic operations:

- Center the surface on the screen.
- Move any part of the surface to the center of the screen.
- Rotate about the horizontal axis of the screen.
- Rotate about a vertical axis of the screen.
- Rotate about the center of the screen.
- Zoom in towards the surface.
- Zoom out from the surface.
- Reset; i.e., realign the Screen Coordinate System with the Reference Coordinate system.

5.8.1 Using the Mouse

You can use the mouse to change the view. All actions take place when the mouse button is released.

Centering Left-button-click the mouse cursor on a point on the surface to have that point moved to the center of the screen. Subsequent rotations and zooms are performed about this new center point. This also defines the origin for measurements displayed in the status bar.

Rotation Rotation about any of the three screen axes can be performed with a left-button-drag of the mouse cursor in the display window, as if grabbing and spinning the object:

- To rotate about the horizontal axis, drag the cursor up or down the vertical axis.
- To rotate about the vertical axis, drag the cursor left or right across the horizontal axis.
- To rotate about the center, drag the cursor in the desired direction near a side of the window.

Rotation is only performed about a single axis (i.e. left/right or up/down or clockwise/counterclockwise) in a single click-and-drag. The amount of rotation is proportional to the length of the drag.

Zoom Right-button-drag the mouse in the display window to zoom: drag up or right to zoom in; down or left to zoom out. The amount of zoom is proportional to the length of the drag.

5.8.2 Using the Keyboard

See Section 7 for the list of keyboard shortcuts that you can use to change the view. When using the keyboard, you can make view changes in four different amounts, as shown in Table 1. Select your 'base' amount from the **View / Movement** menu. Hold down Shift, Ctrl and Shift+Ctrl while pressing the movement keys to select successively smaller amounts. For example, when your base amount is 'fine', Shift selects 'very-fine', Ctrl selects 'ultra-fine'.

	Rotate	**Zoom**
Normal	30.0°	141.4%
Fine	5.0°	107.2%
Very Fine	1.0°	101.4%
Ultra Fine	0.2°	100.2%

Table 1: View movement amounts. The zoom amounts are such that five at one zoom speed is equivalent to one at the next faster speed.

5.9 Making Measurements

The third panel on the status bar displays the x, y and z coordinates of the surface point underneath the cursor, and, in parentheses, its linear distance from the origin. These measurements are in millimeters, and in the Screen Coordinate System (see Section 5.7). When in Camera view (**View / Camera** has been selected), this status panel displays the x, y and z coordinates and the Euler angles of the Wand (with **Transmitter is Reference** selected) or the Receiver (with **Receiver is Reference** selected).

5.10 Sweep List Dialog Box

The **Sweep List** dialog box can be used to remove sweeps that make up the Raw Surface. To open the dialog box, select **View / Sweep List**.

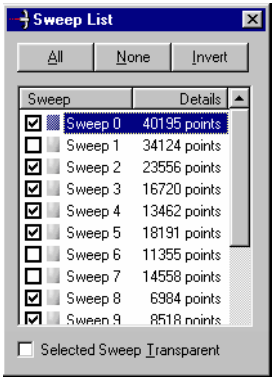


Figure 14: The **Sweep List** dialog box.

The dialog box (shown in Figure 14) contains a list item for each sweep. The second column gives the number of points in the sweep. You can resize the dialog box to make room for more list items.

To highlight a sweep, click on the list item. The color of the sweep in the main window will be changed to the preview color (normally red). The actual display of the highlighted sweep depends on the status of the **Selected Sweep Transparent** check box in the **Sweep List** dialog box. If unchecked, only those parts of the sweep not concealed by other sweeps will be colored red, as shown in Figure 15(a). If checked, the shading will vary depending on the surrounding sweeps:

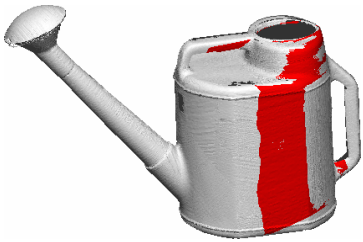
Darkest red: this sweep is the only one covering this part of the surface.

Medium red: this sweep is on top, but has other sweep(s) behind it.

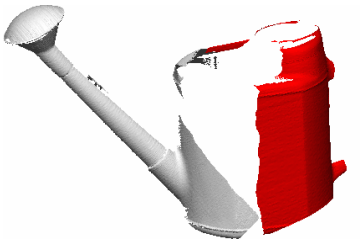
Lightest red: this sweep is underneath other sweep(s).

To hide a sweep, click on the check-mark to the left of the list item. Hidden sweeps will not be drawn in the main window, as shown in Figure 15(b). Hidden sweeps are ignored when a Raw Surface is processed or exported, but when you save Raw Data in HLS format all sweeps, visible or not, are saved. You can hide sweeps at any time, and you can continue scanning after hiding sweeps.

Once it is open, you can manipulate the **Sweep List** dialog box from the main window. Press `[` and `]` (square brackets) to move the selection up and down, and press `'` (single quote) to toggle the visibility of the selected sweep.



(a) With all sweeps.



(b) With some hidden sweeps.

Figure 15: A Raw Surface with a highlighted sweep. With (a) all sweeps visible and (b) only a few sweeps visible.

6 Saving, Processing, and Exporting

The FastSCAN software deals with two surfaces, the Raw Surface and the Export Surface. Figure 16 shows the processes that are used to generate these two surfaces.

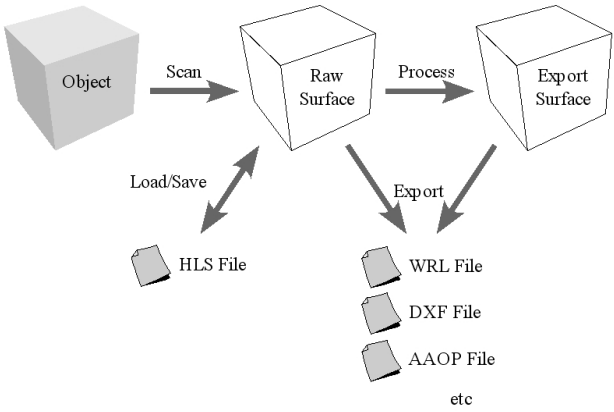


Figure 16: Objects and processes in FastSCAN.

Raw Surface The Raw Surface is the unprocessed data that is gathered from the scanner. It is made up of several separate sweep objects. Sweeps may overlap and intersect each other, contain holes, and may have been scanned with differing resolutions.

Export Surface The Export Surface is generated from the raw surface, a process which involves:

- Merging overlapping sweeps.
- Changing and standardizing the resolution.
- Simplifying facets.
- Limiting the number of objects contained in the Raw Surface.

You can swap the display between Raw Surface and Export Surface. If processing is required it will be invoked automatically when selecting **View / Export Surface**.

6.1 Loading and Saving Raw Surfaces

You can save the Raw Surface of a scan by selecting **File / Save**. FastSCAN Cobra uses its own proprietary HLS file format. You can reload these files using **File / Load**;

no other file format can be reloaded. Loaded scans can be processed and exported, but you cannot add extra more sweeps to them.

Note

If you want to export to a different format or to change the processing parameters at some time in the future, make sure that you save the scan as a HLS file so that you can reload it.

6.2 Exporting the Raw or Export Surface

You can 'export' the Raw or Export Surface in a variety of industry-standard formats using **File / Export / Raw Surface** and **File / Export / Export Surface**. For an explanation of the various export formats see Section 6.5. You can export scans with respect to the Screen or Reference coordinate systems, just choose the appropriate option in the **Coordinate System** section of the **File / Export** dialog box. Note that you cannot reload any of these formats back into the FastSCAN program.

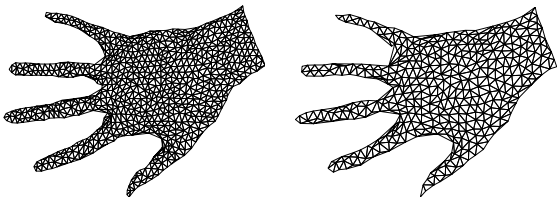
When saving the Raw Surface, some file formats support saving each sweep as a separate object in the file, just check the **Separate Sweeps** control. This allows you to manipulate the sweeps easily in another application. Current only Wavefront (.OBJ) format supports separate sweeps, and only for triangle meshes.

6.3 Generating the Export Surface

The parameters that affect the Export Surface are contained in the **Export Surface Control** dialog box (accessed via **View / Export Surface Control**). The following several sections describe these parameters.

6.3.1 Resolution

Increasing the **Resolution** value in the **Export Surface Control** dialog box reduces the number of points and facets. This means a smaller export file and subsequently faster rendering of exported scans when loaded into other programs. Decreasing the value produces a larger, slower and more detailed mesh. Figure 17 shows the same object exported at two different resolutions.



(a) 6 mm Resolution (b) 9 mm Resolution

Figure 17: The same object at different export resolutions. The 6 mm version (a) has 1378 triangles, while the 9 mm version (b) has only 704 triangles.

6.3.2 Export Smoothing

When scanning, you will probably scan some parts of the surface with multiple sweeps. These sweeps will not always align perfectly; possible causes include:

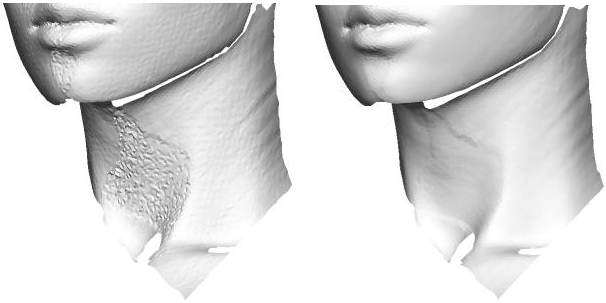
- Small errors in the scanner measurements.
- Metal objects interfering with the magnetic locater.
- The object or reference moved unintentionally during scanning.

If FastSCAN does not merge the overlapping sweeps correctly when it creates the Export Surface then the surface will appear 'blistered'. Figure 18 shows how the blistering occurs as the Export Surface jumps between the points in the two sweeps.

Figure 18: An illustrative example of how a blistered surface (black line) can form between two misaligned sweeps (gray lines).

The **Export Smoothing** parameter controls how much smoothing FastSCAN uses when merging sweeps. A low value creates a more detailed surface, but will fail to merge more widely separated sweeps. A higher value will merge sweeps better, but will remove more surface details. Typically, you will want to use the smallest possible value that still merges sweeps correctly. Figure 19 shows the effect of different values.

The amount of blistering that occurs is also dependent on the **Resolution** parameter. Smaller values will have more blistering while larger values may be completely free of it. This means that if you lower the **Resolution** value you may also need to raise



(a) Export Smoothing at 0.5 mm.

(b) Export Smoothing at 2 mm.

Figure 19: Two exports of the same surface at different Export Smoothing. In (a), the sweeps did not combine correctly, while in (b) they did.

the **Export Smoothing**.

If you cannot find a suitable value such that FastSCAN merges sweeps while preserving detail, try the following:

- Undo the sweep(s) over the problem area, and rescan if necessary.
- Rescan the object after removing metal objects from the scanning area.
- Fix the object and the reference securely so that they cannot move during scanning.
- Try to avoid scanning one area with multiple overlapping sweeps.
- Ensure that the Wand, Transmitter and object are kept as close to each other as is conveniently possible. This also applies to the Reference Receiver if it is the reference device.
- Perform a User Calibration to ensure the optics are correctly aligned (see Section 8).

6.3.3 Simplification

You can also reduce the complexity of the Export Surface by activating simplification, which generates fewer facets for roughly the same accuracy. Check the **Simplify Facets** box to enable it.

6.3.4 Object Limit

You may find that your surface contains parts of background objects (such as the scanning table) that you did not mean to scan; the camera can pick-up partial profiles on objects behind the target object. You can use the **Limit Objects to** control to remove these extra bits of surface, but only if they are disconnected from, and smaller than, all the pieces of the main object.

Check the **Limit Objects to** box and enter the number of objects *N* that you wish to be preserved. The export process will remove all the smaller objects, leaving only the *N* largest.

If this method fails, you can:

- Edit the Export Surface afterward using a separate application.
- Rescan after covering background objects in a black cloth (or similar arrangement) in order to suppress the laser return from them.

6.3.5 Surface Information

If you want to know some of the statistics of your surfaces, the **Export Surface Control** dialog box also includes this information. For the Raw Surface, it shows the number of sweeps, profiles, points and facets. For the Export Surface, it shows the number of points and facets and the surface area.

6.4 Batch Processing

The batch processing interface allows you to setup the parameters for processing several scan files, then process them all at once. This replaces the old command line interface. Figure 20 shows the batch processing dialog.

Select **File / Export / Batch Process** to open the **Batch Processing** dialog. On the left of the dialog is the list of scans to process. If you currently have a scan open it will be placed in this list, otherwise the list will be empty.

The **Add** button, beneath the list, adds a new scan, copying the settings from the last scan in the list. If you want to process several scans with the same settings, then configure the first scan before adding the rest. To remove the selected scan from the list, use the **Remove** button.

On the right of the list is group of controls for changing the settings for the currently selected scan. The top-most box displays the input scan file name, which cannot be changed. The **Export Surface Control** button opens the **Export Surface Control**

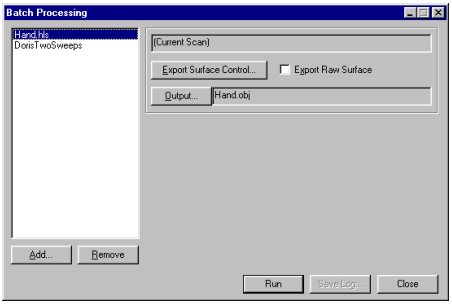


Figure 20: The batch processing dialog.

dialog, where you can specify the processing parameters for the scan. Alternatively, to export the raw data without processing, check the **Export Raw Surface** button. The final control displays, and allows you to change, the output format and filename. The initial output filename is derived from the scan filename.

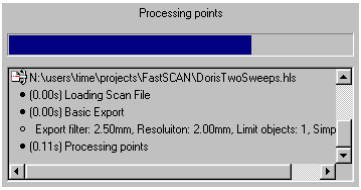


Figure 21: The progress bar and message log displayed during batch processing.

At the bottom-right of the dialog is the **Run** button. This starts the processing, exporting every scan in the list, in order, according to the parameters you have specified. While running, the empty part of the dialog displays a progress bar (showing progress of the current step) and a message log (see Figure 21). The message log displays which scans and processing steps have been run, the processing parameters, and any errors that are generated. When processing is complete the **Save Log** button allows you to save a this message log to a text file.

6.5 Export File Formats

FastSCAN Cobra can export to a number industry standard file formats. Each format often has multiple variants (IGES has over 200). It is not possible to support them all, but we have attempted to support the most popular variant(s) for each type. If you have difficulties importing one of these files into your 3D-manipulation program, try

exporting another variant and/or another file type, as most programs will import multiple file types/variants. If you continue to have difficulties, please contact Polhemus with the following information:

- FastSCAN software version.
- The importing application name and version.
- The problem file.
- A file that is known to load into your application program.

6.5.1 3D Studio (.3DS)

The file format used by 3D Studio and supported by 3D Studio Max; also supported by other programs. This format supports cloud of points or triangular mesh data.

6.5.2 AAOP (.AOP)

AAOP, named after the American Academy of Orthotists and Prosthetists, is a CAD/CAM file format used by orthotic and prosthetic CAD/CAM vendors. A special license is required to access the AAOP Export Wizard.

6.5.3 ASCII (.TXT)

ASCII stores a plain-text list of vertex locations. Each line contains the x, y, and z location of a single vertex, separated by spaces. Comment lines begin with a percent character '%'.

```
% Copyright (c) 1995-2000, Applied Research Associates NZ Ltd. All rights reserved.
% Ascii 3D points file created by FastSCAN.exe V3.2.0 on Fri May 05 11:48:23 2000
% Res: 1.00, Objs: 1, Simp: N, Coord: View, Surf: Points, EOL: CRLF
% 27812 3D points, x y z per line
37.70 71.41 -84.81
37.97 71.16 -83.95
```

6.5.4 AutoCAD Drawing Interchange Format (.DXF)

The file format used by Autodesk AutoCAD, and other CAD programs. Supports cloud of point or triangular mesh data, the latter as 3DFACE or POLYLINE, which may be supported differently by various programs.

6.5.5 IGES Initial Graphics Exchange Format (.IGS)

IGES is a complex format that can be used to exchange many different types of data. These files tend to be much larger than other export formats. FastSCAN Cobra can save three different types of IGES:

Entity 116 A cloud of points.

Entity 128 A triangle mesh with each triangle represented as a separate B-spline surface. This format is very inefficient and many programs may run out of memory when trying to load it.

Entity 106 A triangle mesh with optional normal vectors. This is the preferred mesh format as it is more efficient than Entity 128.

6.5.6 Inventor (.IV)

The native file format of SGI Inventor. Supports triangular mesh data only.

6.5.7 Lightwave Object (.LWO)

The file format of the Lightwave animation software; also supported by other programs. This format supports cloud of points or triangular mesh data.

6.5.8 MATLAB (.MAT)

A binary data file format used by The MathWorks MATLAB. Supports cloud of points or triangular mesh data, both with optional vertex normal vectors. The file will contain at most four MATLAB variables:

Points A 3-by-N matrix where each column is a vertex location.

Normals A 3-by-N matrix giving the vertex normal vector for each vertex.

Facets A 3-by-M matrix where each column defines a triangle as three indexes into the list of Points.

Info A string containing information about the file.

6.5.9 Polyworks Scan (.PSL)

This is a binary format file designed for the interchange of 3D scans. Data is saved in scan-lines with vectors indicating the direction of the laser.

6.5.10 Stereo Lithography (.STL)

A common format that supports triangle meshes. FastSCAN supports both ASCII and binary STL files (binary is faster and creates a much smaller file).

The specification of binary STL says that data should be stored in little-endian (also known as network) byte order. Most programs actually seem to use big-endian (Intel and MIPS) order, so that is the default. If a file fails to load, particularly on a little-endian machine, try exporting with byte swapping enabled. This problem does not exist for ASCII mode STL files. The byte order of various architectures is:

Big-Endian Intel, MIPS.

Little-Endian SPARC, PowerPC, Motorola 68000, and most others.

6.5.11 VRML Virtual Reality Modeling Language (.WRL)

VRML is a scene description language common on the Internet. There are different versions of VRML; FastSCAN produces the older 1.0 version, which is still widely supported. Generated files contain a single triangular mesh object and a camera object based on the current view.

6.5.12 Visualization Toolkit (.VTK)

The file format of the "Visualization Toolkit" (VTK). Supports both cloud of points and triangle mesh. Only the ASCII file format is supported.

6.5.13 Wavefront Object (.OBJ)

The file format used by the Alias|Wavefront software and supported by other programs. This is an easily parsed ASCII format, which supports cloud of points and triangular mesh, the latter with optional vertex normal vectors.

6.6 Command Line Interface

Warning

We no longer recommend using the command line interface. Where possible, you should use the batch processing dialog instead.

You can also run FastSCAN.exe in non-interactive 'batch' mode from the Windows command prompt. This may be useful, for example, when a number of objects have been scanned and saved as HLS files, but still need to be exported. For detailed information on the command syntax, issue the FastSCAN command with the `/?` qualifier, i.e.:

```
"C:\Program Files\Polhemus\FastSCAN\FastSCAN" /?
```

Note that the quotes are needed because of the space in "`Program Files`", and that the directory must be changed if FastSCAN has been installed in other than the default location.

6.7 FastSCAN Pipe Interface

The FastSCAN Pipe Interface (FPI) allows another application program to access 3D scan data from FastSCAN in real-time while you are scanning an object. For further details on how to use the FPI, please refer to the file `FastScanPipeInterface.txt` in the directory named PipeInterface in the FastSCAN directory, typically:

```
C:\Program Files\Polhemus\FastSCAN\PipeInterface
```

7 Hot Key List

Menu Item	Shortcut	Wand Trigger
File / New Scan	Ctrl+N	Triple click
File / Save	Ctrl+D	
View / Camera	Ctrl+C	
View / Raw Surface	Ctrl+R	
View / Export Surface	Ctrl+E	
View / Points	Ctrl+P	
View / Wireframe	Ctrl+W	
View / Flat Shaded	Ctrl+F	
View / Smooth Shaded	Ctrl+S	
View / Stereo Control	Ctrl+T	
View / Export Control	Ctrl+X	
View / Sweep List	Ctrl+L	
View / Stylus List	Ctrl+Shift+L	
View / Viewpoint / Center	Insert	
View / Viewpoint / Reset	Home	
View / Viewpoint / Zoom In	Page Up	
View / Viewpoint / Zoom Out	Page Down	
View / Viewpoint / Rotate Left	Left Arrow	
View / Viewpoint / Rotate Right	Right Arrow	
View / Viewpoint / Rotate Up	Up Arrow	
View / Viewpoint / Rotate Down	Down Arrow	
View / Viewpoint / Roll Left	Delete	
View / Viewpoint / Roll Right	End	
View / Movement / Normal	Ctrl+1	
View / Movement / Fine	Ctrl+2	
View / Movement / Very Fine	Ctrl+3	
View / Movement / Ultra Fine	Ctrl+4	
decrease movement size by 1	Shift+*key*	
decrease movement size by 2	Ctrl+*key*	
decrease movement size by 3	Shift+Ctrl+*key*	
Scanner / Undo Sweep	Ctrl+Z	Double click
Scanner / Redo Sweep	Ctrl+Y	
Sweep List / Up	[	
Sweep List / Down	]	
Sweep List / Toggle Sweep	′ (single quote)	
Stylus List / Up	{	
Stylus List / Down	}	
Stylus List / Toggle Point	″ (double quote)	

8 Calibration

The Wand is fully calibrated before it leaves the factory. However, for optimum performance you may need to check and (if necessary) adjust the calibration from time to time. This process is quick and convenient.

You should check the Wand calibration if:

- The Wand has been knocked or dropped.
- You notice the visual quality of the scans deteriorate.
- You have not used the FastSCAN Cobra for some time.
- You are about to commence a particularly difficult or demanding scan.

The **Calibration Correction** option in the **Scanner** menu allows you to correct the calibration of the Wand. A user correction is not equivalent to a full factory calibration and it may not be possible to restore the scanner to its original condition if it has been badly misaligned. To ensure that your FastSCAN Cobra stays in calibration, always handle it with care.

Windows 2000/XP Note

Under Windows 2000 or XP, you will need Power User or higher privileges if you are going to perform a Calibration Correction.

8.1 Overview

To collect the data required for a Calibration Correction, you must scan the Calibration Target with eight separate sweeps. Make the first four sweeps with a Wand to Target distance of 100 mm and then last four at 200 mm. Make each sweep, at each range, at a 90-degree rotation from the previous sweep, as shown in Figure 22.

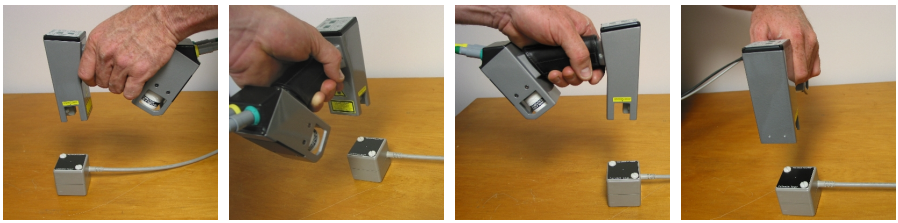


Figure 22: Scanning the Calibration Target at four different angles.

Figure 23: The Transmitter with the Calibration Target attached.

Note that while in the Calibration Correction mode, FastSCAN Cobra monitors the Wand to Calibration Target distance and will only accept data when the distance is within ± 20 mm of the nominal value, i.e.:

100 mm data: range is 80 mm to 120 mm.
200 mm data: range is 180 mm to 220 mm.

You may find that maintaining the correct distance while scanning the Calibration Target is awkward at first. To help, the computer "beeps" as you scan the Calibration Target if the data is within the acceptable range.

8.2 Calibration Correction Procedure

Perform the Calibration Correction as follows (please read all the steps before beginning):

1. Set up the scanning environment as described in Section 5.2. It is *imperative* that you keep metal objects (such as computers, monitors and metal furniture) at least 1m away from the scanning area.

2. Attach the Calibration Target to the Transmitter using the two nylon screws provided (see Figure 23). The orientation of the target is not important, but you must attach it securely.

3. Place the Transmitter down with the Calibration Target facing upward.

4. Start the FastSCAN program (if you are running Windows 2000 or XP then you must have at least Power User privileges).

5. Select the **Calibration Correction** option from the **Scanner** menu. The background color of the FastSCAN window will change to black, and the **Calibration Correction** dialog box will appear.

6. Set the sensitivity control to position 1.

7. Hold the Wand at a range of 100 mm (4") above the Calibration Target.

8. To confirm that you are holding the Wand at the correct distance, pull the trigger to the Preview Position (halfway in) and scan over the target. If the range was acceptable, your computer will beep as you scan the Calibration Target. Otherwise, continue previewing at different Wand to Target ranges until you hear beeping.

9. When at the correct range, pull the trigger fully in, and *slowly and evenly* scan over the target, from top to bottom, and release the trigger.

10. If the range was acceptable, you will hear beeping as you scan the Calibration Target, *and a red spot will appear on the screen*.

11. Rotate the Wand by 90 degrees and repeat step 9. Repeat this process two more times. Thus, four spots are collected at relative orientations of 0 degrees, 90 degrees, 180 degrees and 270 degrees respectively (as shown in Figure 22).

12. Repeat Steps 9 and 11, but at a range of 200 mm (8"), and with the sensitivity control at position 2.

13. After you have made all eight measurements, there should be two clusters of points in the FastSCAN window (as shown in Figure 24), one representing the data collected at 100 mm and the other the data collected at 200 mm. In each cluster, there should be four red spots.

14. Once you have confirmed that all the required data is present, click the **Compute Correction** button.

15. The variance (RMS) of the collected data will be displayed before and after the calibration parameters have been calculated. A successful Calibration Correction should have an RMS of $< 0.20 - 0.30$ mm.

Notes:

- You must collect the 100 mm data first.
- Windows 2000 or XP users must have at least Power User privileges.

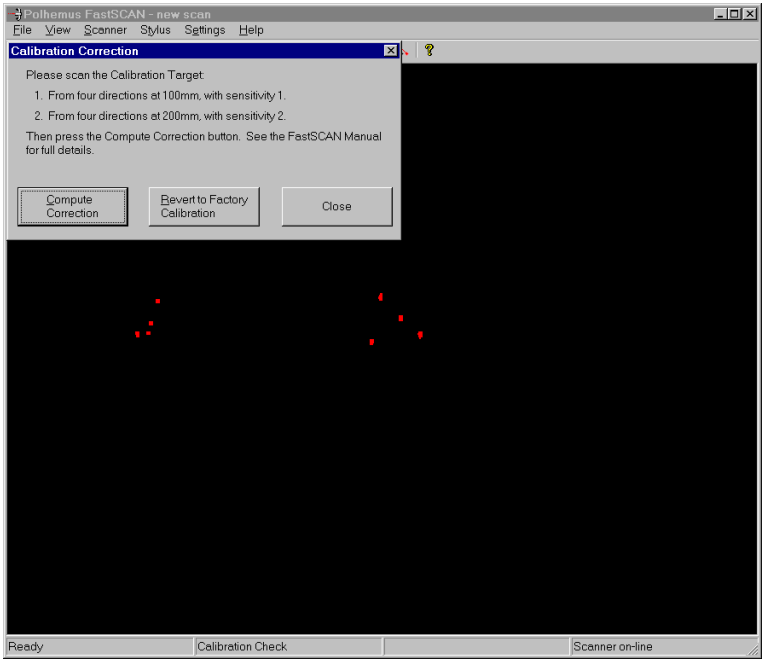

Polhemus FastSCAN - new scan
File View Scanner Stylus Settings Help
Calibration Correction
Please scan the Calibration Target:
1. From four directions at 100mm, with sensitivity 1.
2. From four directions at 200mm, with sensitivity 2.
Then press the Compute Correction button. See the FastSCAN Manual for full details.
Compute Correction
Revert to Factory Calibration
Close
Ready
Calibration Check
Scanner on-line

Figure 24: The FastSCAN window with all the eight points.

- If desired, the last sweep (or in this case, the point) can be removed with a double click of the trigger, or all data can be removed with a triple click.
- To help reduce artifacts, the data is restricted to points within the vicinity of the Calibration Target, so it will not matter if you place the Transmitter and Target on a light-colored surface.
- Should the Transmitter already be bolted to a surface, then the Calibration Target may be placed on the opposite face. It is imperative, however, that the target is mounted securely.
- To remove all Calibration Corrections made to date, click the **Revert to Factory Calibration** button.

9 Troubleshooting FAQ

Q. The status bar of the FastSCAN program continues to show 'Scanner off-line'—what has gone wrong?

A. If this is a recent problem, and you have been scanning successfully up until now, run through the following checklist:

- Ensure you do not have another FastSCAN program still running from an earlier session (possibly minimized).
- Ensure that power is getting to the PU. The green 'Power' light on the front panel should be on.
- Ensure that power is getting to the Wand. The green 'Power' light on the Wand should be on.
- Check the connection of all the cables. You *must* plug in the Reference Receiver at all times, even if you are not using it.

Q. I have just done a scan and there is nothing on the screen. Why?

A. It is likely that the scanned surface is out of view. Try centering the scan—select **Center** from the **View / Viewpoint** menu (or press the Insert key). If you are new to scanning, check that you are holding the trigger in the scanning position so the orange Scan light on the Wand glows.

Q. I have "floating" fragments of surfaces in my scan that are unrelated to the object—what's happening?

A. The Wand's camera may occasionally view a bright, broad spectrum light source (e.g., sunlight from a window) that mimics the light of the laser. It is advisable to keep windows shuttered, avoid bright lights above and behind the scanning area, and to set the sensitivity control as low as possible. To check whether extraneous light is being detected, select **View / Camera** (which displays what the camera is seeing), and cover the laser. Anything visible in the display is then due to extraneous light.

Q. How close do I need to keep the FastSCAN Cobra components?

A. To ensure both high resolution and high accuracy, keep the Wand close to the object's surface during scanning, but no closer than 80 mm to keep within the field of view. If you are using the Receiver, parts of the surface closer to it will scan more accurately. Try to keep the Transmitter close to the Wand and Receiver, as accuracy deteriorates with distance, but no closer than 100 mm to avoid signal overload. The maximum separation of any two components is about 750 mm.

Q. How far away do I have to keep metal objects from the scanner?

A. Operation in the presence of metal objects interferes with the tracking of the Wand and so degrades performance. As long you keep any large metal objects at least one meter from the Wand, the Transmitter, and the object you are scanning, they should not pose a problem.

Q. When I do an export, the Export Surface looks very "bumpy"—what is wrong?

A. Successive sweeps over the same part of the surface have not merged properly using the **Resolution** and **Export Smoothing** set in the **Export Surface Control** dialog box. Try increasing the **Export Smoothing** (see Figure 19). If this does not help, go through the checklist at the end of Section 6.3.2.

Q. I am trying to process some scans on another computer, and the FastSCAN program seems to be affecting the printer—how can I stop this?

A. If you are using the FastSCAN program on a computer with a printer attached instead of the scanner, you should uncheck **Driver enabled** in the **Scanner Properties** dialog box. You will then be able to print normally.

10 Limited Warranty and Limitation of Liability

10.1

Polhemus warrants that the Systems shall be free from defects in material and workmanship for a period of one year from the date ownership of the System passed from Polhemus to Buyer. Polhemus shall, upon notification within the warranty period, correct such defects by repair or replacement with a like serviceable item at Polhemus' option. This warranty shall be considered void if the System is operated other than in accordance with the instructions in Polhemus' User Manual or is damaged by accident or mishandling. Parts or material which are clearly expendable or subject to normal wear beyond usefulness within the warranty period such as lamps, fuses, etc., are not covered by this warranty.

10.2

In the event any System or portion thereof is defective, Buyer shall, within the warranty period, notify Polhemus in writing of the nature of the defect, remove the defective parts and, at the direction of Polhemus Customer Service, ship such parts to Polhemus. Upon determination by Polhemus that the parts or Systems are defective and covered by the warranty set forth above, Polhemus, at its option shall repair or replace the same without cost to Buyer. Buyer shall pay all charges for transportation and delivery costs to Polhemus' factory for defective parts where directed to be sent to Polhemus, and Polhemus shall pay for transportation costs to Buyer's facility only for warranty replacement parts and Systems. Removed parts covered by claims under this warranty shall become the property of Polhemus.

10.3

In the event that allegedly defective parts are found not to be defective, or not covered by warranty, Buyer agrees that Polhemus may invoice Buyer for all reasonable expenses incurred in inspecting, testing, repairing and returning the Systems and that Buyer will pay such costs on being invoiced therefor. Buyer shall bear the risk of loss or damage during transit in all cases.

10.4

Any repaired or replaced part or System shall be warranted for the remaining period of the original warranty or thirty (30) days, whichever is longer.

10.5

Warranties shall not apply to any Systems which have been:

(a) repaired or altered other than by Polhemus, except when so authorized in writing by Polhemus.

(b) used in an unauthorized or improper manner, or without following normal operating procedures; or

(c) improperly maintained and where such activities in Polhemus' sole judgement, have adversely affected the Systems. Neither shall warranties apply in the case of damage through accidents or acts of nature such as flood, earthquake, lightning, tornado, typhoon, power surge or failure, environmental extremes or other external causes.

10.6

POLHEMUS DOES NOT WARRANT AND SPECIFICALLY DISCLAIMS THE WARRANTY OF MERCHANTABILITY OF THE PRODUCTS OR THE WARRANTY OF FITNESS OF THE PRODUCTS FOR ANY PARTICULAR PURPOSE. POLHEMUS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, EXCEPT OF TITLE AND AGAINST PATENT INFRINGEMENT, OTHER THAN THOSE SPECIFICALLY SET FORTH HEREIN.

10.7

IN NO EVENT SHALL POLHEMUS BE LIABLE UNDER ANY CIRCUMSTANCES FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO LOSS OF PROFITS OR REVENUE. WITHOUT LIMITING THE FOREGOING POLHEMUS' MAXIMUM LIABILITY FOR DAMAGES FOR ANY CAUSE WHATSOEVER, EXCLUSIVE OF CLAIMS FOR PATENT INFRINGEMENT AND REGARDLESS OF THE FORM OF THE ACTION (INCLUDING BUT NOT LIMITED TO CONTRACT NEGLIGENCE OR STRICT LIABILITY) SHALL BE LIMITED TO BUYER'S ACTUAL DIRECT DAMAGES, NOT TO EXCEED THE PRICE OF THE GOODS UPON WHICH SUCH LIABILITY IS BASED.

11 Indemnity Against Patent Infringement

Polhemus shall have the right at its own expense, to defend or at its option to settle, any claim, suit or proceeding brought against Buyer on the issue of infringement of any United States patent by any product, or any part thereof, supplied by Polhemus to Buyer under this Agreement. Polhemus shall pay, subject to the limitations hereinafter set forth in this paragraph, any final judgement entered against Buyer on such issue in any such suit or proceeding defended by Polhemus. Polhemus at its sole option shall be relieved of the foregoing obligations unless Buyer notified Polhemus promptly in writing of any such claim, suit or proceedings, and at Polhemus' expense, gave Polhemus proper and full information and assistance to settle and/or defend any such claim, suit or proceeding. If the product, or any part thereof, furnished by Polhemus to Buyer becomes, or in the opinion of Polhemus may become, the subject of any claim, suit or proceeding for infringement of any United States patent, or in the event of an adjudication that such product or part infringes any United States patent, or if the use, lease or sale of such product or part is enjoined, Polhemus may, at its option and its expense: (a) procure for Buyer the right under such patent to use, lease or sell, as appropriate, such product or part, or (b) replace such product or part, or (c) modify such product, or part, or (d) remove such product or part and refund the aggregate payments and transportation costs paid therefore by the Buyer less a reasonable sum for use, damage and obsolescence. Polhemus shall have no liability for any infringement arising from: (i) the combination of such product or part with any other product or part whether or not furnished to Buyer by Polhemus, or (ii) the modification of such product or part unless such modification was made by Polhemus, or (iii) the use of such product or part in practicing any process, or (iv) the furnishing to Buyer of any information, data, service or application assistance. Buyer shall hold Polhemus harmless against any expense, judgement or loss for infringement of any United States patents or trademarks which results from Polhemus' compliance with Buyer's designs, specifications or instructions. Polhemus shall not be liable for any costs or expense incurred without Polhemus' written authorization and in no event shall Polhemus' total liability to Buyer under, or as a result of compliance with, the provisions of this paragraph exceed the aggregate sum paid to Polhemus by Buyer for the allegedly infringing product or part, exclusive of any refund under option (4) above. The foregoing states the entire liability of Polhemus, and the exclusive remedy of Buyer, with respect to any actual or alleged patent infringement by such product or part.

12 Customer Service

If you encounter any problems with your FastSCAN Cobra, help is just a telephone call away. Call 802/655-3159 (800/357-4777 U.S. and Canada) and ask for Customer Service. For the most part, our Customer Service engineers can handle your problems over the telephone and get you back into the fast lane right away. If the problem requires repair of your instrument, the Customer Service engineer will issue you a Return Merchandise Authorization (RMA) number. Polhemus strongly suggests retaining the original shipping container for your FastSCAN Cobra in the event that the instrument may require repair. Please do not return any instrument without an RMA number, as it will not be accepted. If your instrument is still under warranty, Polhemus will repair it free of charge according to the provisions of the warranty as stated in Section 10 of this document. The proper return shipping address is:

Polhemus
40 Hercules Drive
Colchester, Vermont 05446

Telephone (voice):	(802) 655-3159
Toll Free (USA & Canada):	(800) 357-4777
Telephone (FAX):	(802) 655-1439
Email:	techsupport@polhemus.com

Software upgrades for licensed users are available from www.fastscan3d.com.

POLHEMUS
First in the third dimension®

P.O. BOX 560, 40 HERCULES DRIVE
COLCHESTER, VT 05446

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http://www.polhemus.com/